Vermillion Creek-

Monitoring Stations- SC520, SC645 & SC681
USGS Gaging Station- 06888000 (Vermillion Creek) 4/22/1936-6/30/1946, 1/1/1954-6/30/1972, & 2/1/2002-Current; 06888300 (Rock Creek) 10/1/1958-9/30/1965
Included area-

HUC 8: 10270102

HUC 10: 01; 02

HUC 12: 01, 02, 03, 04, 05, 06, 07, 08, 09; 01, 02, 03, 04, 05

Streams Flowing to Monitoring Station-

Station	Name	Segment #
SC520	Vermillion Creek-	16
Lower Vermillion	Vermillion Creek-	17
	Indian Creek-	20
	Jim Creek-	52
	Adams Creek-	53
	Spring Creek-	54
	Pomeroy Creek-	59
SC645	Rock Cr-	21
Rock Creek	Rock Cr, E Fork-	22
	Pleasant Hill Run-	23
	Wilson Cr-	50
	Darnells Cr-	51
	Mud Cr-	56
	Brush Cr-	57
	Elm Slough-	58
SC681	Vermillion Cr-	17
Upper Vermillion	Vermillion Cr-	18
	French Cr-	19
	Mulberry Cr-	42
	Hise Cr-	43
	Mud Cr-	44
	Cow Cr-	45
	Coal Cr-	46
	Gilson Cr-	47
	Spring Cr-	48

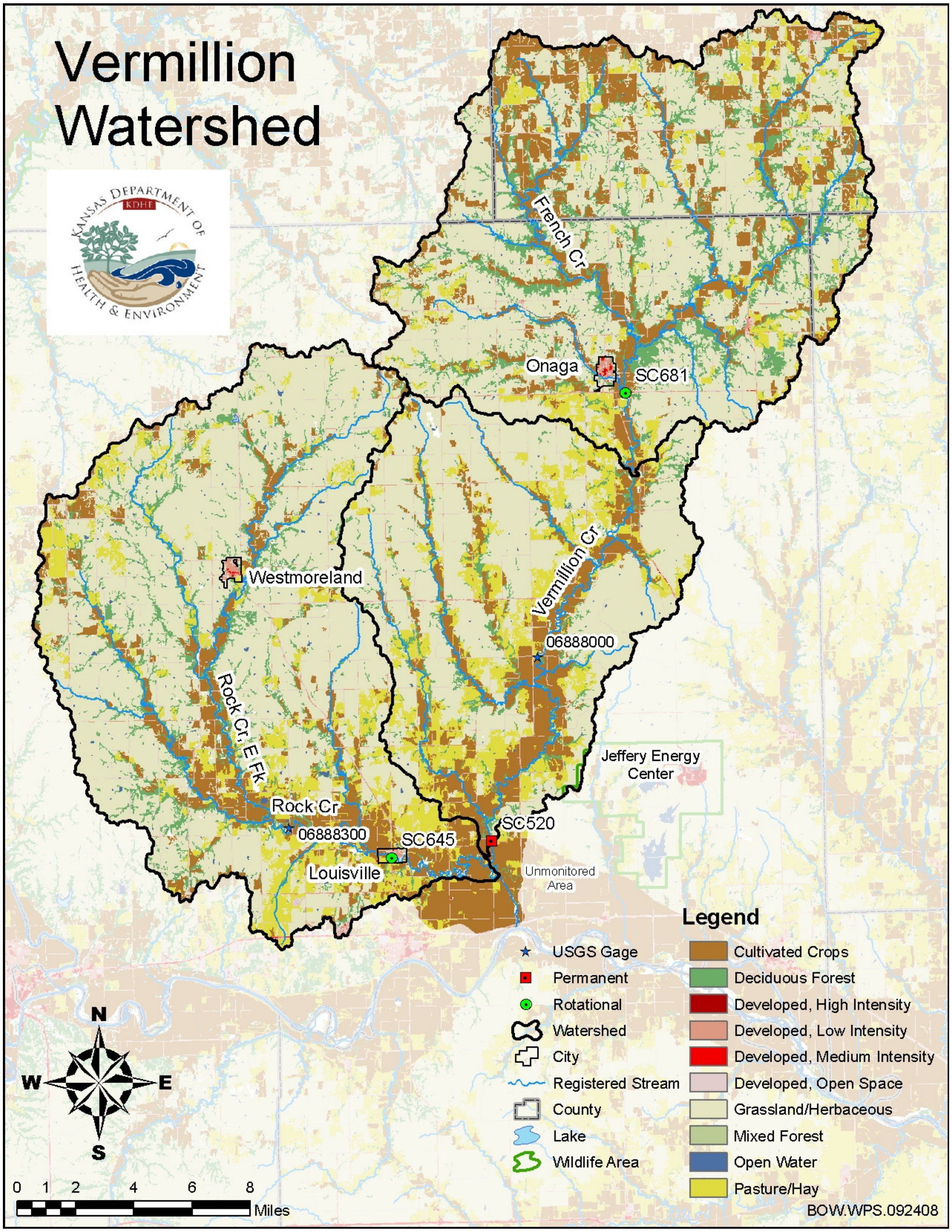
Monitored Watershed Size- 506.5 square miles
SC520- 124.5 square miles
SC645- 193.8 square miles
SC681- 188.2 square miles
Unmonitored Downstream Area – 8.1 square miles
Land use-

	Lower Vermillion	Rock Creek	Upper Vermillion
Permanent Grass	73.56%	71.97%	61.44%
Cropland	16.34%	13.16%	19.19%
Forest	6.41%	10.24%	14.59%
Developed Land	3.35%	4.09%	4.31%

Counties- Pottawatomie, Nemaha, Jackson & Marshall
Cities- Westmoreland, Onaga, Louisville
Rock Creek Watershed District- Includes only the streams draining to Rock Creek (HUC10 – 1027010201); does not include Vermillion Creek or streams monitored by SC520 or SC681 (HUC10 – 1027010202)
2000 Population- Overall- 5,880[1]
Lower Vermillion - 595
Rock Creek - 3,370
Upper Vermillion - 2,184
Kansas House Districts-50, 61, 62, 106
Kansas Senate Districts- 1 & 21
2008 303(d) impaired waters- Biology (SB520, High Priority) *E. coli* Category 3 (some evidence of impairment, but insufficient data to determine if water quality criteria are met) (SC645)
TMDLs- Bacteria, approved 1/26/2000 (SC520, SC681) (High Priority)
NPDES Permitted Facilities- Corning MWTP (M-KS94-OO01), Havensville MWTP (M-KS22-OO01), Louisville MWTP (M-KS37-NO01), Onaga MWTP (M-KS53-OO01), Westmoreland MWTP (M-KS75-OO01), Wheaton MWTP (M-KS79-OO01), Pottawatomie Co. S.D. – Fostoria (M-KS93-NO01), Rock Creek High School (M-KS75-NO04), Hamm (I-KS79-PO02)
Permitted Confined Animal Feeding Operations-30

Animal Type	Total Animals
Beef	8,547
Chickens Dry	600000
Dairy	362
Swine	23,338
Swine, misc. others	14,066

[1] Individual monitoring station populations add up to greater than the total population due to census boundaries that cross watershed boundaries.



Overview map of the Vermillion Creek watershed. Land use from the 2001 National Land Cover Dataset.

Stream Chemistry-

The monitoring stations in the Vermillion Creek area have moderate to poor overall rankings. Rock Creek has the second-to-worst overall condition, with the worst overall rank of all stations for *E. coli*, and poor rankings for nutrients and suspended solids. Upper Vermillion Creek has a very poor ranking for total phosphorus, and moderate to poor rankings for the other parameters. Lower Vermillion Creek appears to be benefiting from some dilution or in-stream processing of nutrients and bacteria reduction, with better rankings for these parameters than the upstream station. However, lower Vermillion Creek has a very poor ranking for suspended solids, suggesting some increase in sediment loading in the area monitored by SC520. The elevated TSS values seen at SC520 may be related to the impairment listing for biology at that site, particularly if the springtime TSS concentrations inhibit the reproduction and colonization of species that reproduce only once per year.

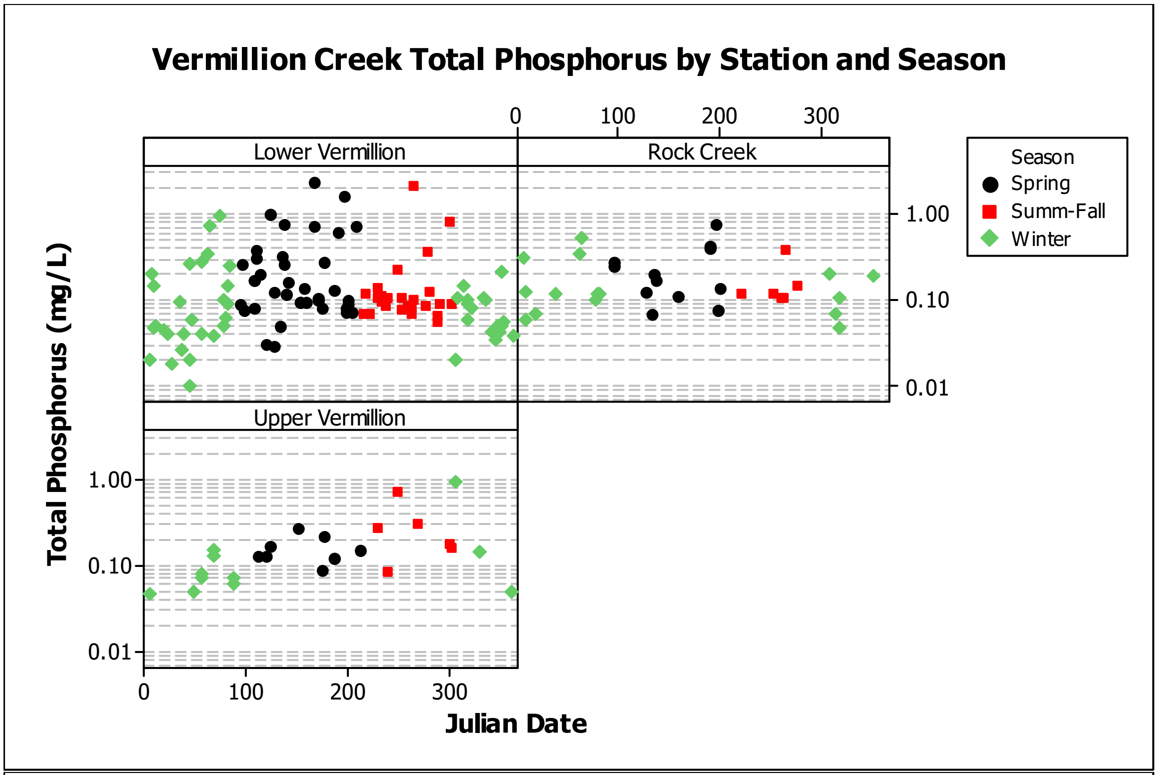
Rock Creek and Lower Vermillion Creek experience their highest pollutant concentrations during the spring season (April – July), with some reductions during summer/fall (August – October), and the lowest concentrations during the winter (November – March). The seasonality is strongest for TP, TSS & *E. coli*, and more moderate for TN. Rock Creek has relatively little variation between the summer/fall and winter for TP, TSS, kjeldahl nitrogen, and total organic carbon, though turbidity is notably higher during the summer/fall than the winter. Upper Vermillion Creek shows a somewhat different pattern, with elevated concentrations of nitrogen, phosphorus and organic carbon during the summer/fall period. Caution should be used when interpreting these results for nitrogen and carbon, due to their small sample size, though they appear consistent with phosphorus results which have a larger sample size over a longer period of time. Similar caution should be applied to the *E. coli* results for both Rock Creek and Upper Vermillion, where very small sample sizes limit our ability to reach significant conclusions. More detailed monitoring of *E. coli* at Rock Creek is being done, consistent with the current water quality criteria, which require a 5 sample, 30 day geometric mean be calculated, and these results should improve our understand of this pollutant.

Due to the short recent record at the USGS gaging station, limited conclusions can be drawn regarding the linkage between flow and pollutant concentration. However, some significant indicators are already visible, even with only five years of discharge data. For example, total phosphorus concentrations at the three monitoring sites have different patterns. Stations SC520 (Lower Vermillion) & SC645 (Rock Creek) fit the overall pattern observed in Kansas waters where nonpoint sources are significant. There is variation around the median, and seasonal variation consistent with flow patterns expected based on regional climate. However, SC681 (Upper Vermillion) has a U-shaped curve, indicating high concentrations at low flow, with some dilution at moderate flows, and increases in concentration again at high flows. This pattern is typical of streams under the influence of point source discharge, where concentrated waste streams strongly influence concentrations at low flows, become diluted as flows increase, until high flows introduce non-point sources and loads into the stream. The city of Onaga has a four-cell lagoon system that discharges not far upstream from SC681, however they are not required to monitor phosphorus at this time, nor are they required to monitor discharge volume, so no estimate of their contribution to the load at SC681 can be made. While mechanical plant wastewater systems typically remove most of the suspended load prior to discharge, lagoons sometimes do not effectively remove suspended algae, which could explain why TSS values at SC681 also demonstrate a U-shaped pattern. This is also consistent with the high correlation between total nitrogen and kjeldahl nitrogen observed at SC681, where discharged algae might be expected to contribute a larger portion of the overall nitrogen load. Lower Vermillion Creek (SC520) may be showing some signs of a U-shaped distribution, but any such effect appears to be diluted by the time the stream reaches that station. Caution should be used when applying gage data to sites other than those which are co-located with the chemistry collection point. In the absence of co-located sites, nearby gages can provide a general understanding of the likely flow conditions at independently located sites.

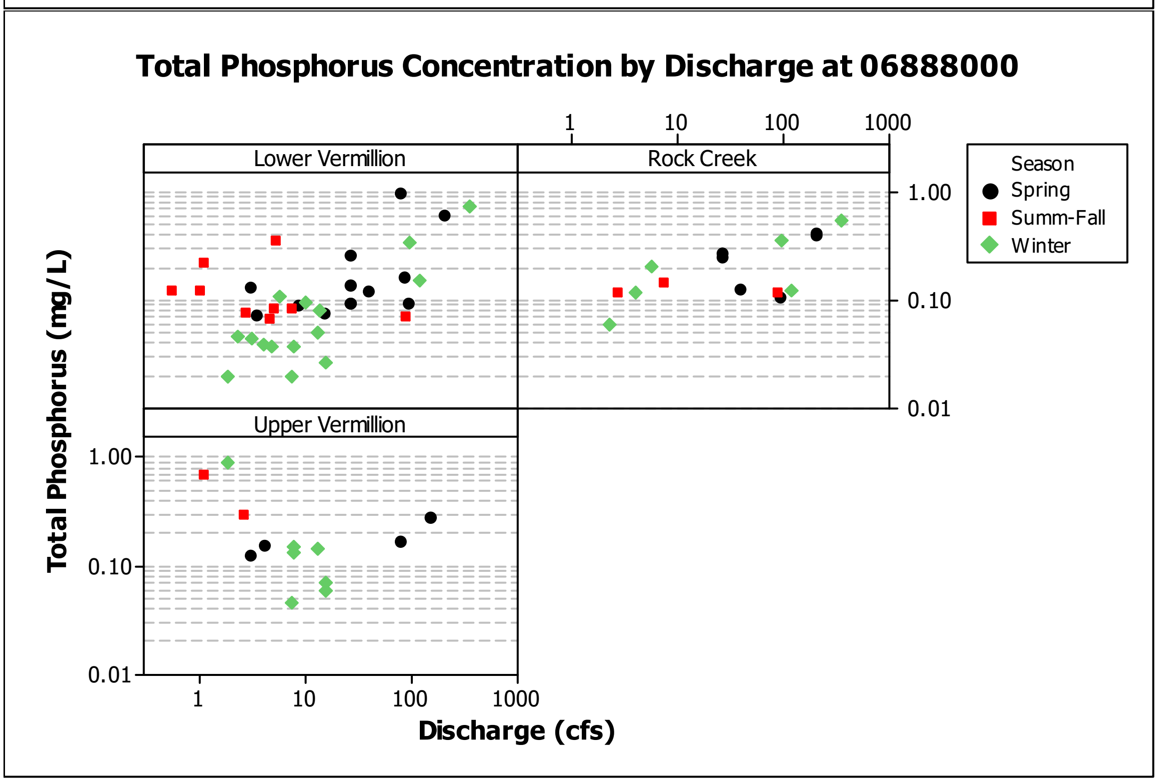
Biological monitoring data collected in Vermillion Creek indicates that most of the samples do not indicate a fully supported biological (macroinvertebrate) community. Some caution may be noted due to the poor distribution of sample dates, where the two recent (since 1999) samples collected in mid-summer have the best overall rankings, while many of the poorly performing samples were collected in May (4) or late fall (2). This could indicate a seasonal impairment occurring during the spring. Until there are more comprehensive data, no such determination can be made. The presence of elevated spring TSS loads may also be related to the poor scores from May. The recent scores still indicate some level of impairment of aquatic life in Vermillion Creek. Improvements from pollutant reductions might generate more suitable habitat.

Site	Season	Turbidity Median	TSS Median	TP Median	TN Median	Kjeldahl Median	*E.coli* Median	TOC Median
Lower Vermillion SC520	Overall	16.5 (112)	38.5 (112)	0.095 (111)	0.825 (53)	0.508 (53)	98 (31)	4.903 (46)
SC520	Spring	33.9 (39)	56 (39)	0.124 (39)	0.96 (18)	0.516 (18)	156 (9)	5.5235 (16)
SC520	Summer-Fall	18.2 (28)	38.5 (28)	0.09 (27)	0.8525 (12)	0.7245 (12)	82.5 (8)	4.97 (11)
SC520	Winter	9.31 (45)	16 (45)	0.06 (45)	0.705 (23)	0.478 (23)	36 (14)	4.191 (19)
Rock Creek SC645	Overall	21.5 (34)	33.5 (34)	0.1215 (34)	0.984 (23)	0.607 (23)	433 (16)	5.4515 (16)
SC645	Spring	37.25 (12)	44.5 (12)	0.189 (12)	1.289 (8)	0.894 (8)	3165.5 (6)	6.7375 (6)
SC645	Summer-Fall	20.05 (6)	25 (6)	0.117 (6)	0.7625 (4)	0.557 (4)	110 (3)	4.054 (3)
SC645	Winter	11.15 (16)	23.5 (16)	0.119 (16)	0.941 (11)	0.519 (11)	86 (7)	5.371 (7)
Upper Vermillion SC681	Overall	15 (25)	34 (25)	0.136 (25)	0.89 (13)	0.74 (13)	108 (7)	4.721 (13)
SC681	Spring	30.8 (8)	60 (8)	0.1455 (8)	1.1085 (4)	0.7795 (4)	635 (2)	5.5605 (4)
SC681	Summer-Fall	15.5 (6)	55 (6)	0.23 (6)	1.9715 (2)	1.8215 (2)	108 (1)	7.818 (2)
SC681	Winter	7.4 (11)	16 (11)	0.072 (11)	0.51 (7)	0.36 (7)	30.5 (4)	4.241 (7)

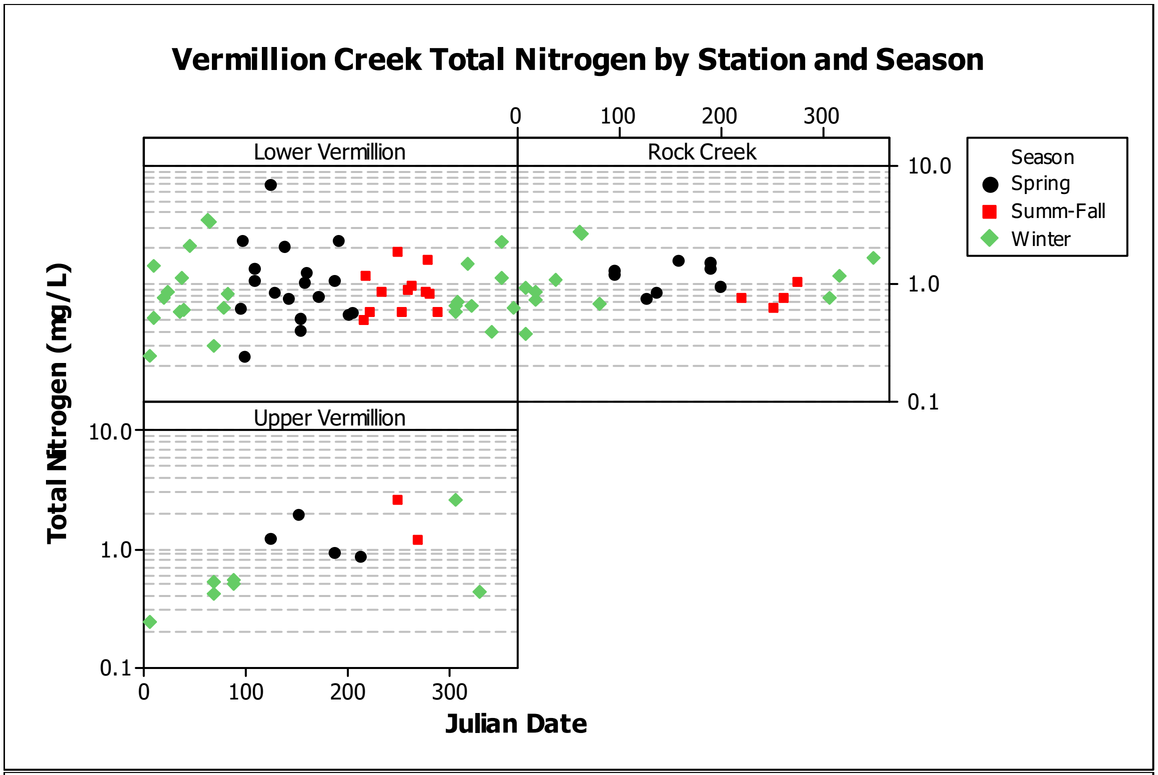
Numbers in parenthesis indicate sample size.

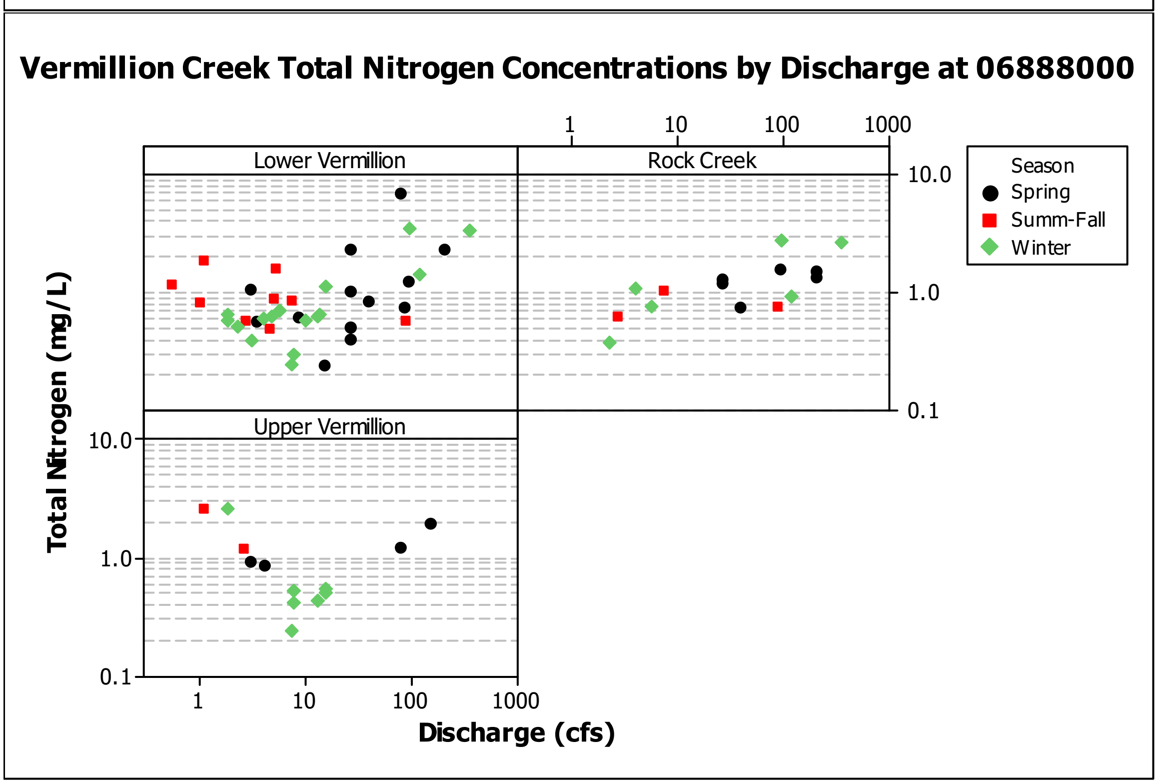


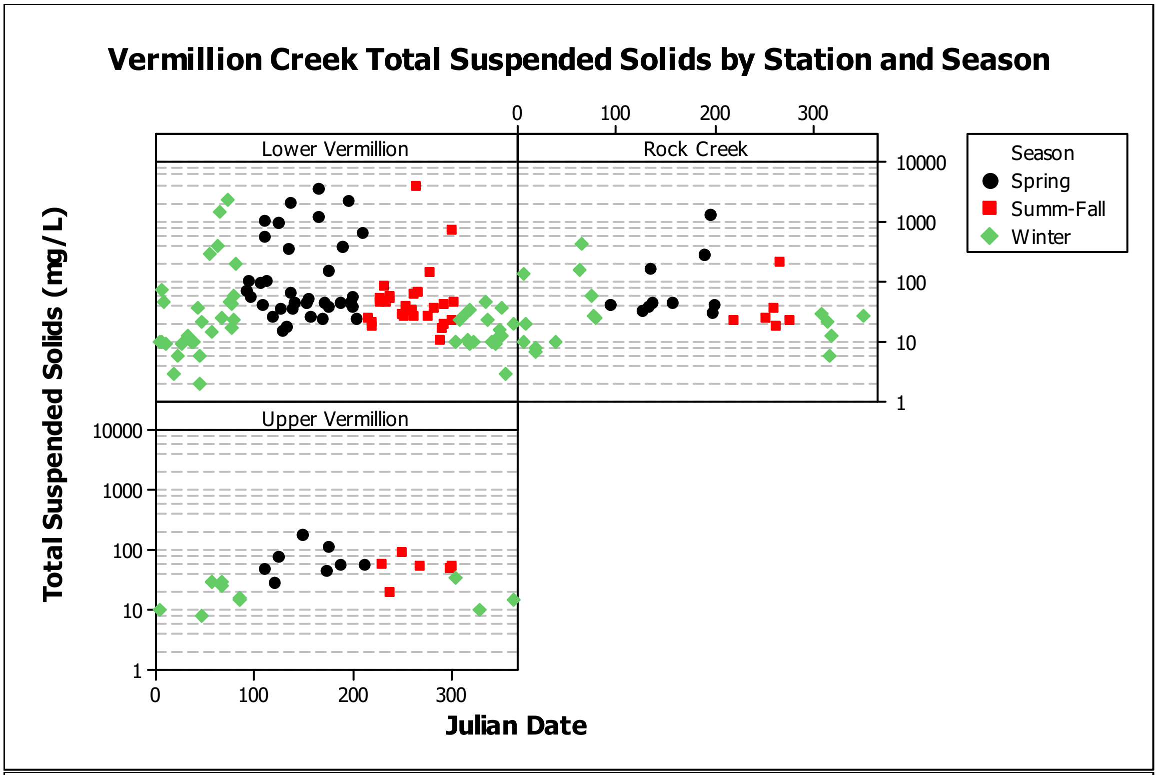
Vermillion Creek Total Phosphorus by Station and Season
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Phosphorus (mg/L)
1.00
0.10
0.01
0
100
200
300
Julian Date



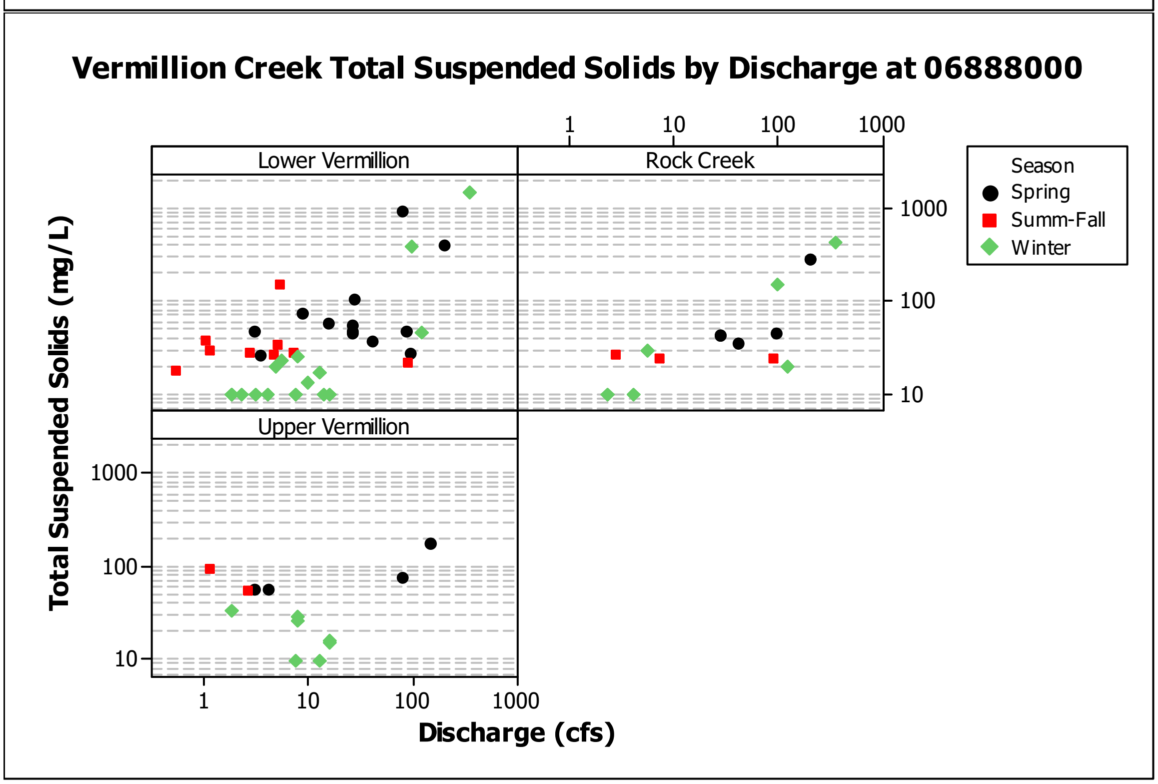
Total Phosphorus Concentration by Discharge at 06888000
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Phosphorus (mg/L)
1.00
0.10
0.01
1
10
100
1000
Discharge (cfs)


Vermillion Creek Total Nitrogen by Station and Season
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Nitrogen (mg/L)
10.0
1.0
0.1
0
100
200
300
Julian Date

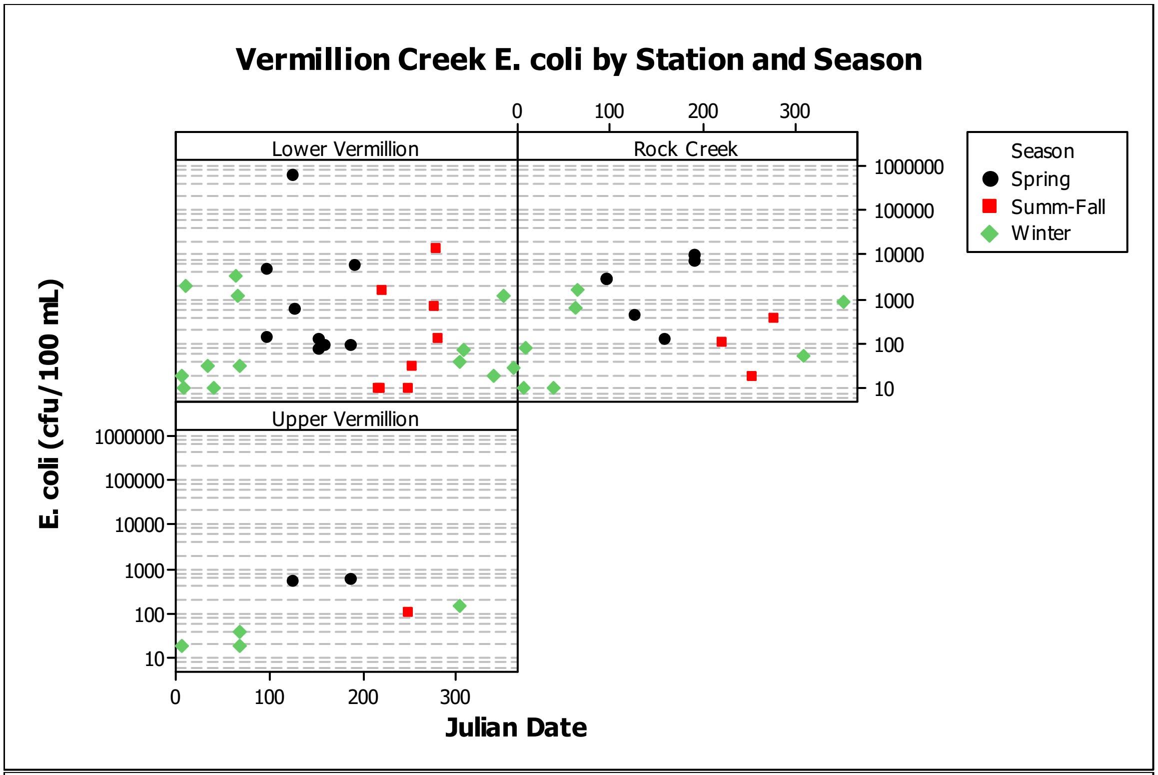

Vermillion Creek Total Nitrogen Concentrations by Discharge at 06888000
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Nitrogen (mg/L)
10.0
1.0
0.1
1
10
100
1000
Discharge (cfs)



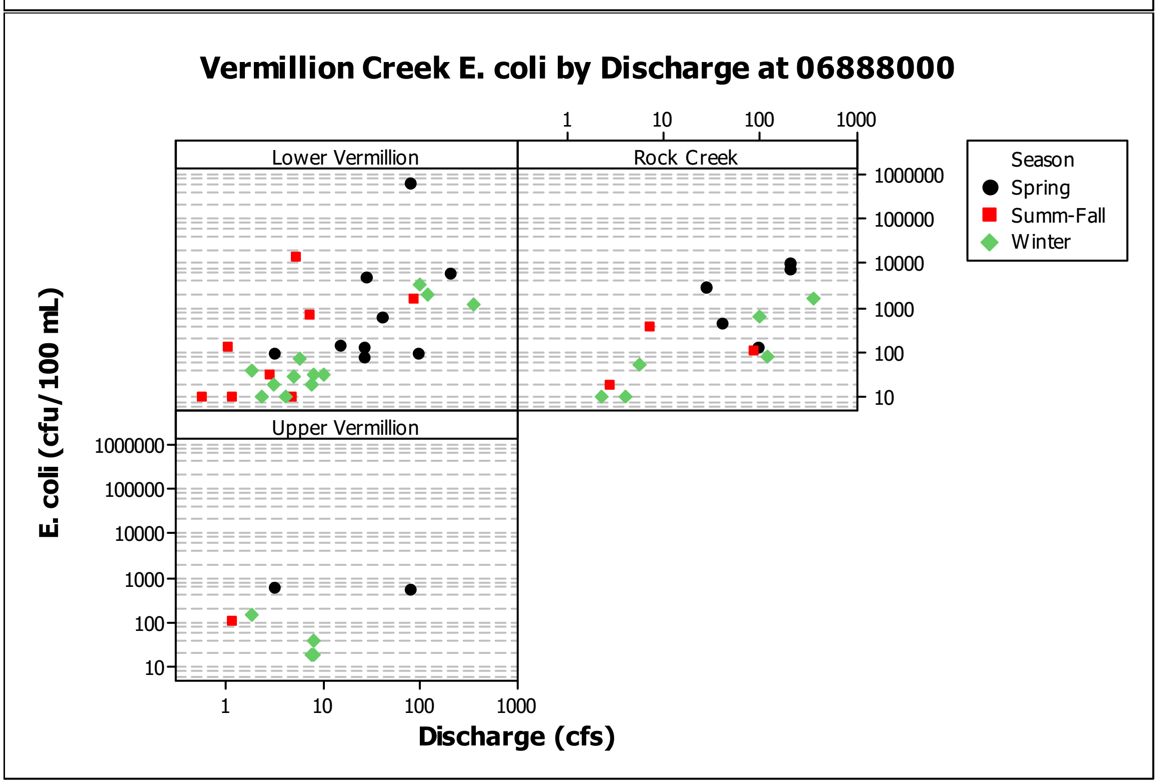
Vermillion Creek Total Suspended Solids by Station and Season
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Suspended Solids (mg/L)
Julian Date
0
100
200
300
1
10
100
1000
10000



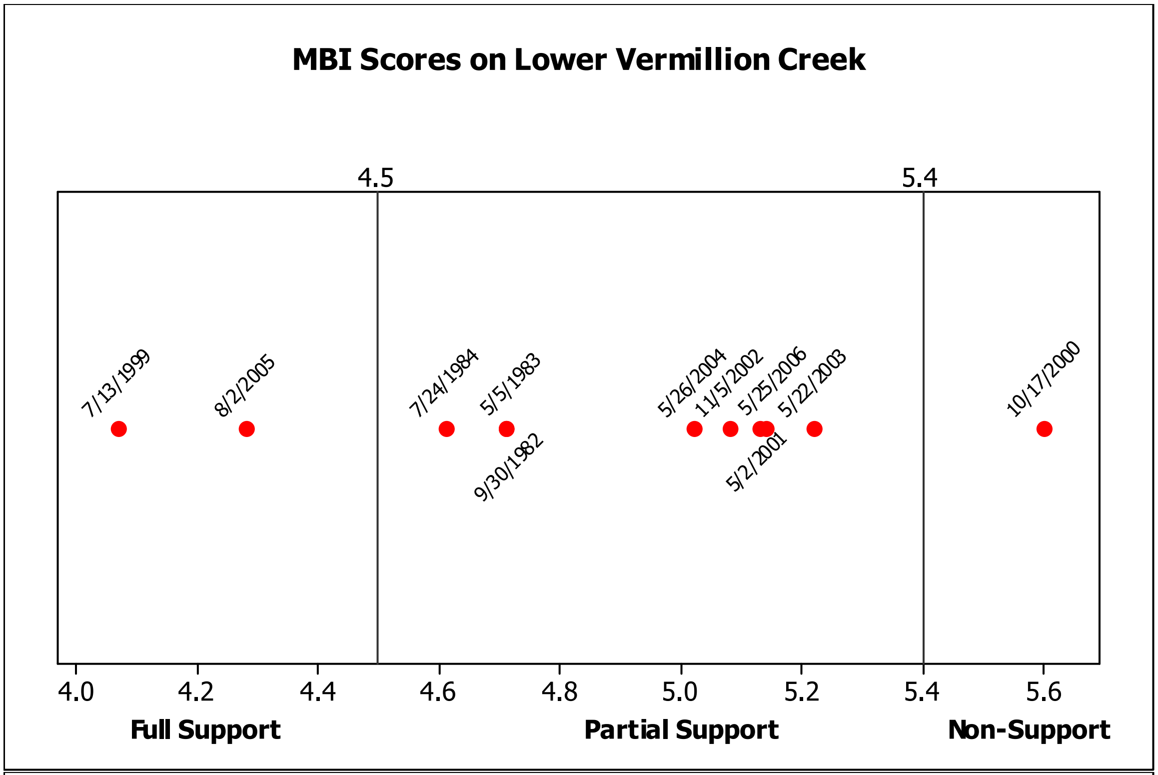
Vermillion Creek Total Suspended Solids by Discharge at 06888000
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
Total Suspended Solids (mg/L)
Discharge (cfs)
1
10
100
1000

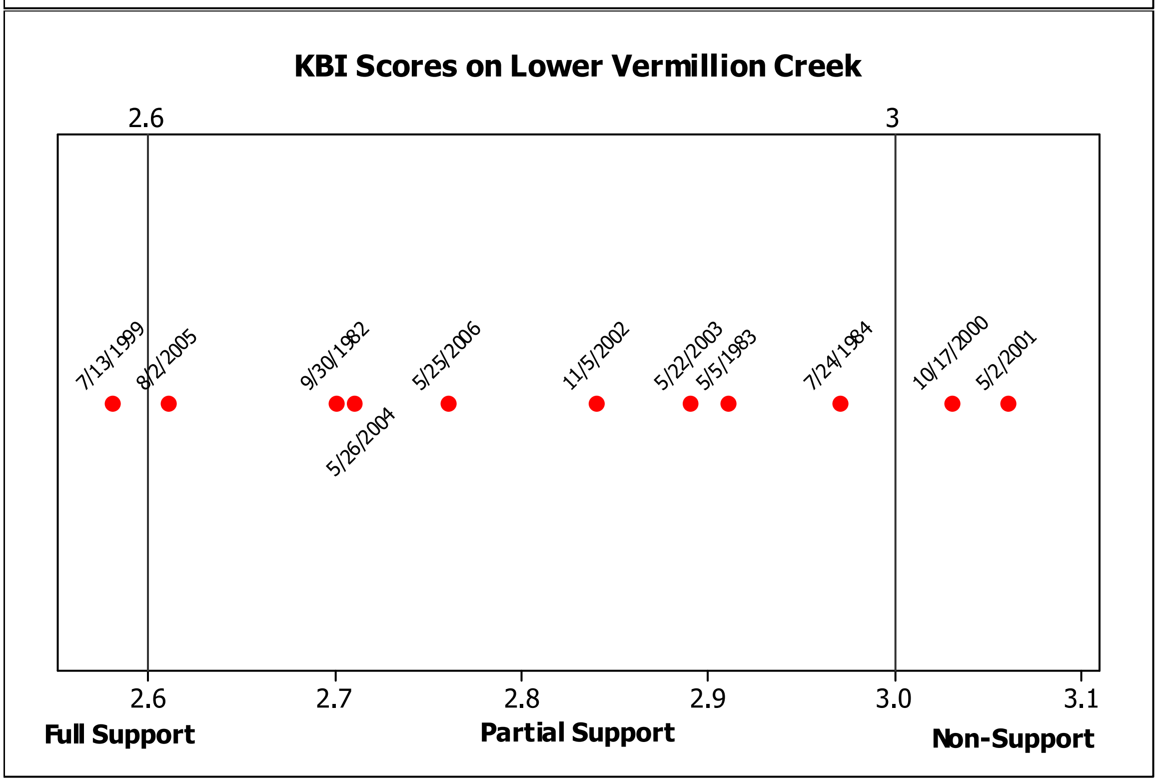


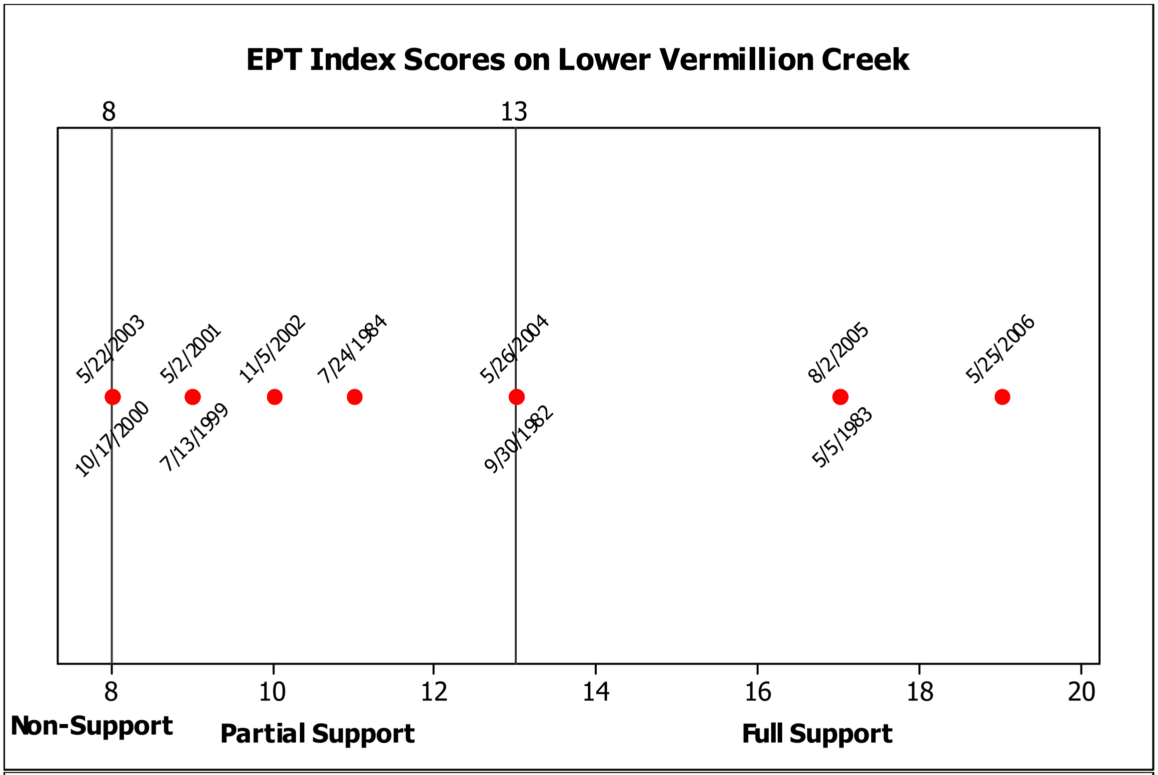
Vermillion Creek E. coli by Station and Season
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
E. coli (cfu/100 mL)
Julian Date
0
100
200
300
10
100
1000
10000
100000
1000000

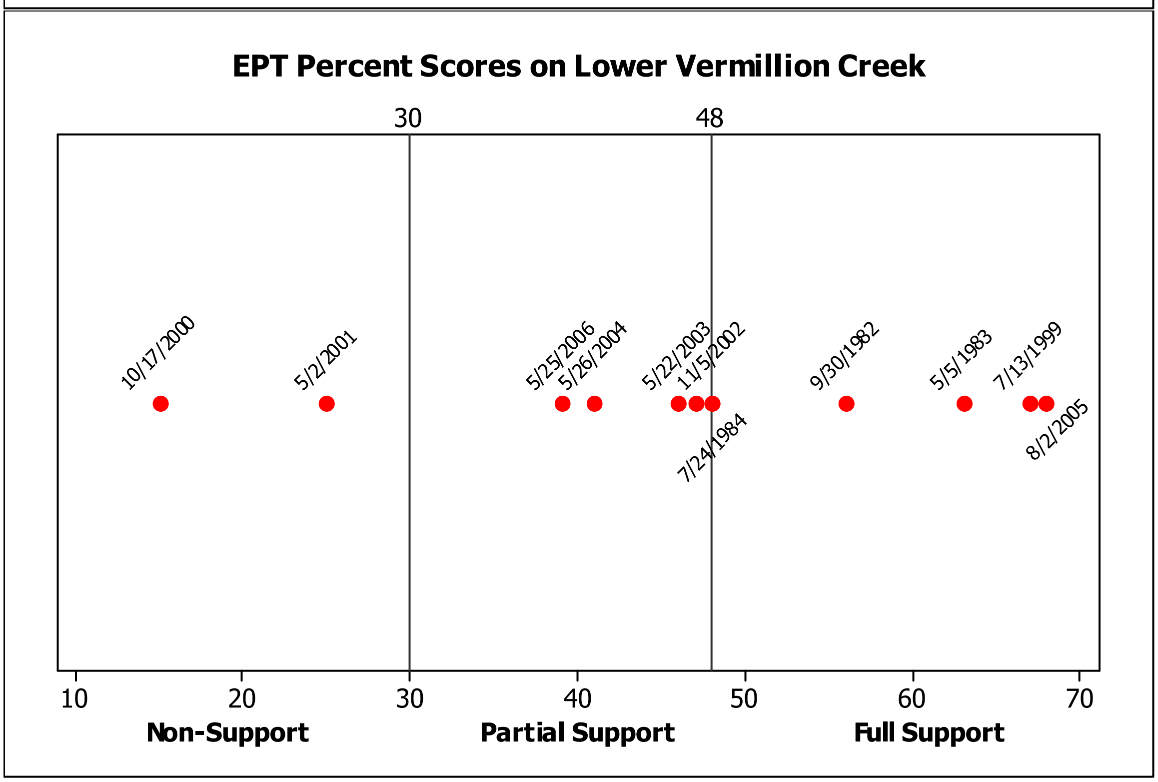


Vermillion Creek E. coli by Discharge at 06888000
Lower Vermillion
Rock Creek
Upper Vermillion
Season
Spring
Summ-Fall
Winter
E. coli (cfu/100 mL)
Discharge (cfs)
1
10
100
1000
10000
100000
1000000


MBI Scores on Lower Vermillion Creek
4.5
5.4
7/13/1999
8/2/2005
7/24/1984
5/5/1983
9/30/1982
5/26/2004
11/5/2002
5/25/2006
5/22/2003
5/2/2001
10/17/2000
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
Full Support
Partial Support
Non-Support

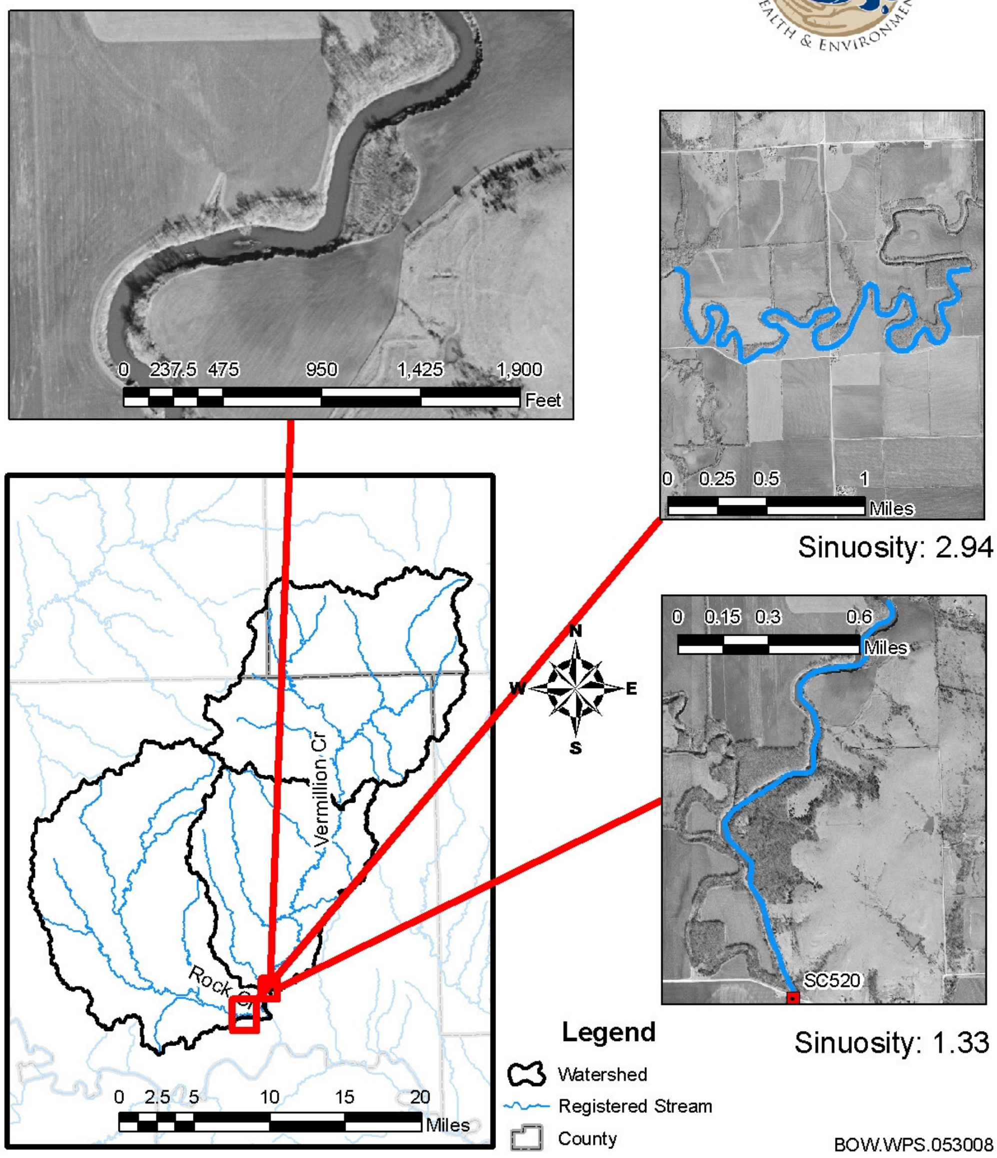

KBI Scores on Lower Vermillion Creek
2.6
3
7/13/1999
8/2/2005
9/30/1982
5/26/2004
5/25/2006
11/5/2002
5/22/2003
5/5/1983
7/24/1984
10/17/2000
5/2/2001
2.6
2.7
2.8
2.9
3.0
3.1
Full Support
Partial Support
Non-Support





Streambank stabilization may play an important role in improving water quality in the Vermillion Creek watershed. One meter resolution aerial photographs were used to identify a number of potential unstable streambanks in the lower reaches of the watershed. Inspection of stream channel sinuosity also suggests that channelization has occurred, and may be contributing to the observed water quality.

Vermillion Creek Watershed
Streambank Erosion Point
Potential Channelization



Vermillion Creek has also been channelized downstream of the junction of Vermillion Creek and Rock Creek, visible in this image from the 2006 NAIP photograph. The historic channel is located as a wooded belt just to the east of the current channel, and provides a case study in the reduction of channel complexity that typically occurs during channelization. This area is part of the unmonitored portion of the watershed, and the land use in this part of the watershed is essentially all row crop production. A similar channelization effort on Soldier Creek has resulted in well documented head-cutting of the stream, lowering the base elevation of the creek bed, substantially increasing bank instability, eroding large quantities of bed and bank material and potentially leading to lower groundwater levels.

Uncertainty-

Because concurrent gage data are only available recently with the stream chemistry data, some uncertainty exists about the flow conditions associated with the earlier samples. Very large TSS values likely occurred during very high flow events, which may be less responsive to restoration efforts (Meals, 1990). Previous research (unpublished) by KDHE has indicated that median values are strong descriptors of nutrient related impairments, even in the absence of flow data, when large sample records exist. At this level of analysis it is not possible to determine the relative contributions of overland flow and in-stream processes, including collapsing streambanks. Elevated nitrogen levels could also be indicative of failing on-site wastewater systems, which cannot be ruled out as a potential contributor at this level of analysis. Future restoration efforts in this area would benefit from more water quality data throughout the watershed, to pinpoint potential sources of pollution, and better define the spatial and temporal variation in water quality. Additionally, surveys of stream channel morphology will locate potential sources of major bank instability.

Adaptive Implementation Strategies-

Because this stream exhibits characteristics that are consistent with point source pollution, overland flow and unstable streambank sources, initial efforts could be focused on the lower reaches of Vermillion Creek for streambank efforts, the Rock Creek watershed for bacteria reductions, and below the city of Onaga for the upper reaches of Vermillion Creek. Evaluation of the potential to restore the most downstream reach of Vermillion Creek to its historic channel would help establish the amount of pollutant loading to the Kansas River from this unmonitored lowest segment of Vermillion Creek. Any movement of the channel of this creek would have to evaluate costs associated with major infrastructure, including the Highway 24 and adjacent Union Pacific railroad bridge near the outlet of Vermillion Creek. This watershed shows extensive use of alluvial valleys for row crop production, and shows some signs of poor buffering around the streams, along the lower reaches of Rock & Vermillion Creeks. While forest buffers along major streams are present in some locations in the watershed, they tend to be narrow, and would benefit streams more with additional width. The moderate TP concentrations appear to track the loading pattern of TSS, suggesting improvements in conservation practices may reduce both these contaminants. Preservation and expansion of the existing buffer zone will likely have beneficial effects for all pollutants for many years to come. Placement of grassed waterways and other upland erosion control measures may also reduce the concentrations of TSS in Vermillion Creek and its tributaries.

Because riparian buffering activities typically take three or more years to fully establish themselves, monitoring of post-implementation water quality should be a long-term objective. The existing monitoring record is unlikely to have many high-flow events, due to the design of the sampling program. Because the majority of loads of suspended solids and total phosphorus are likely to occur during a few, relatively large events, a before-and-after sampling program focused on high flow events would determine if efforts lead to significant improvements to water quality. Nitrogen concentrations appear to be less variable than TSS and TP, though concentrations still exceed regional guidance. Wintertime concentrations that usually exceed summer-fall concentrations, as is the case on Rock Creek, suggest that groundwater loading is a probable source of nitrogen, because wintertime flows are typically driven by baseflow from groundwater sources, while some dilution may be occurring during summer when flows are usually somewhat higher than winter flows.

It should be noted that some strategies to reduce nutrient pollution have confounding effects. Tillage and cover strategies that reduce runoff and increase infiltration have been documented in some cases to increase nitrogen infiltration to groundwater. Increased infiltration should reduce phosphorus and sediment loading, and improvements to riparian forest areas are likely to reduce groundwater loading of nitrogen to the stream, while increasing bank stability. Therefore, implementing strategies should target field runoff for sediment and phosphorus loading, and simultaneously implement riparian restoration.

Should streambank stabilization, riparian planting, and other buffering activities in the lower reaches not reduce sediment and nutrient loading to acceptable levels, targeted monitoring may be required to determine sources more accurately. Funding for practices to improve water quality should focus on lands adjacent to streams where cropland is completely unbuffered, and implementation of erosion control practices in the valley along Vermillion Creek, because these areas are more likely to contribute to water quality problems monitored at station 520. Provision of alternate watering sites, and exclusion of cattle from direct access to streams has numerous benefits, and may prove an important component of watershed restoration in this area. Reduced bank trampling increases the stability of streambanks, while also improving the growth and health of riparian trees. Keeping cattle out of streams also reduces direct inputs of nutrients and bacteria to the stream, and buffer areas can filter overland flow reducing pollutant loading from that source as well.

Vermillion Creek and its tributaries presents significant challenges to implementat protection and expansion of the existing riparian buffer has significant potential to improve water quality. While unverified at this level of analysis, the low sinuosity of some of the mainstem segments of Vermillion Creek suggests that channelization has occurred in this area, and unstable banks may be contributing to the concentrations observed. Increasing the streams' connection with its flood plain and widening of permanent vegetation buffers along the streams could require some reductions of current cropland uses by area landowners. Further evaluation will need to be completed to determine the extent of the problem, and establish the costs for implementing conservation activities.